

Difference of α -disks between Seyfert 1 galaxies and Quasars

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Abstract In a previous paper (Bian & Zhao 2002), it was suggested that contamination to the luminosity of galactic nucleus from the host galaxies play an important role in determining parameters of the standard α disk for AGNs. Using the nuclear absolute B band magnitude instead of the total absolute B band magnitude, the central black hole masses, the accretion rates and the disk inclinations to the line of sight for 20 Seyfert 1 galaxies and 17 Palomar-Green (PG) quasars were recalculated. It was found that small value of α is needed in the accretion disk for Seyfert 1 galaxies compared with PG quasars. The difference of α maybe lead to the different properties between Seyfert 1 galaxies and Quasars. Furthermore, we found most of the objects in this sample are not accreting at super-Eddington rates when we adopted the nuclear optical luminosity in our calculation.

Key words: galaxies: active — galaxies: nuclei — quasars: Seyfert.

1 INTRODUCTION

The standard paradigm of AGNs is an accretion disk surrounding a central super-massive black hole. The wide emission lines are coming from the material located in the regions outside the accretion disk called broad line regions (BLRs). With the reverberation mapping method, the sizes of BLRs from the center of AGNs are obtained in 37 nearby AGNs (Ho 1998; Wandel et al. 1999; Kaspi et al. 2000). In our one previous paper (Bian & Zhao 2002), we assume that the gravitational instability of standard thin disks leads to the formation of BLRs, the B band luminosity comes from standard thin disk and the motion of BLRs is virial. Using the accretion disk theory, we determined some parameters of the accretion disk in AGNs, such as the central black hole mass, accretion rates, disk inclinations to the line of sight, α parameter. It was pointed out that the host contribution to the optical luminosity of AGNs had a strong effect on the determination of these parameters of the accretion disk.

Ho & Peng (2001) used the nuclear luminosity in optical and radio bands to discuss the radio loudness of Seyfert nuclei and found that the majority of type 1 Seyfert nuclei is in the

category of radio-loud AGNs. They also found that a strong correlation between the nuclear optical magnitude (M_B^{nuc}) and $H\beta$ luminosity ($L_{H\beta}$) (See their figure 6). Ho (2002) also used this correlation to estimate the nuclear optical luminosity to investigate the relations between radio luminosity, radio loudness, and the black hole mass.

Here we adopted the nuclear absolute B band magnitude (M_B^{nuc}) from the literature (Schmidt & Green 1983; Ho & Peng 2001; Ho 2002) and did the recalculation to obtain the accretion disk parameters according the method introduced in the paper Bian & Zhao (2002). This method used in the paper of Bian & Zhao (2002) was briefly introduced in section 2. The recalculated results are presented in section 3. Section 4 is our conclusion. All cosmological calculations in this paper assume $H_0 = 75 \text{ km s}^{-1}$, $\Omega = 1.0$, $\Lambda = 0$.

2 THE METHOD

2.1 Formulae

Here we briefly introduced the method used in Bian & Zhao (2002). First, using the standard thin disk theory, the B band luminosity (L^B) can be derived from the black hole mass (M), the accretion rate (\dot{M}), and the inclination (i) by

$$L_9^B = 13.8 \dot{M}_{26}^{2/3} M_8^{2/3} \cos i. \quad (1)$$

where $M_8 = M/(10^8 M_\odot)$, $L_9^B = L^B/(10^9 L_\odot)$, and $\dot{M}_{26} = \dot{M}/(10^{26} \text{ g s}^{-1})$.

Second, from accretion disk theory, we can obtain the radius of the gravitational instability (R_{ins}) (Bian & Zhao 2002) by

$$R_{14} = 880 \alpha^{28/45} Q^{-8/9} \dot{M}_{26}^{-22/45} M_8^{1/3}. \quad (2)$$

where $R_{14} = R_{ins}/(10^{14} \text{ cm})$, α is the parameter describing the viscosity for the standard α -disks. Q is the criterion of the gravitational instability. Assuming that the gravitational instability of the accretion disk leads to BLRs, we assume that the BLRs size (R_{BLR}) is equal to instability radius (R_{ins}).

Third, assuming BLRs motion is virial, the FWHM of $H\beta$ (V_{FWHM}) is given by

$$V_3 = 3.89 Q^{4/9} \alpha^{-14/45} \dot{M}_{26}^{11/45} M_8^{1/3} \sin i. \quad (3)$$

where $V_3 = V_{FWHM}/(1000 \text{ km s}^{-1})$.

Using Eq. (1-3), we can calculate the central black hole masses (M), the accretion rates (\dot{M}), and the inclinations (i) knowing absolute B band luminosity (L^B), sizes of the BLRs (R_{BLR}) and FWHMs of $H\beta$ (V_{FWHM}).

2.2 Date

Our sample consists of all AGNs with available BLRs sizes from the reverberation mapping method: 20 Seyfert 1 galaxies (Wandel et al. 1999, Ho 1998), 17 PG quasars (Kaspi et al 2000). For this sample, M_B^{nuc} is available in the literature for all the quasars (Schmidt & Green 1983) and for a number of the Seyfert 1 galaxies (Ho & Peng 2001). For the other Seyfert 1 galaxies, the M_B^{nuc} is obtained from the $M_B^{nuc} - L_{H\beta}$ correlation (Ho 2002). We used M_B^{nuc} instead of the absolute B band magnitude from the Veron-Cetty & Veron (2001) to calculate absolute B band luminosity L^B . The value of M_B^{nuc} is listed in Column (3) in Table 1. The absolute B band magnitude (M_B) from Veron-Cetty & Veron (2001) is also listed in Column (2) in Table 1.

3 RESULTS

We found in Table 1 that for PG quasars M_B^{nuc} is almost equal to M_B , while for Seyfert 1 galaxies M_B^{nuc} is almost larger than M_B , namely, there is much contamination to the luminosity of galactic nucleus from the host galaxies in Seyfert 1 galaxies.

From Table 2, we suggested the reasonable value of α for Seyfert 1 galaxies is about $0.1 \sim 0.01$ if the mean inclination of Seyfert 1 galaxies is about 30° (deg) (Nandra et al. 1997; Wu & Han 2001). Because the uncertainties of Q and the BLRs size don't effect our results too much compared with that of α , we just determined our results uncertainties from the uncertainty of α . We used $\alpha = 0.1$ and $\alpha = 0.01$ to calculate the accretion disk parameters for Seyfert 1 galaxies. The mean values of these three parameters are listed in Table 1. The mean inclination of Seyfert 1 galaxies is $30.4 \pm 4.5^\circ$ (deg), which is consistent with AGNs unification schemes (Urry & Padovani 1995). However, for PG quasars, the reasonable value of α is 1 considering the small mean inclination using smaller values of α . We fixed $\alpha = 1$ and adopted the same method in Bian & Zhao (2002) to calculate these three parameters, which are consistent with the results in Bian & Zhao (2002). Their uncertainties are from the uncertainties of the values of Q and BLRs sizes. The values of black hole mass, accretion rates, accretion rates in units of the Eddington accretion rate, and inclinations are listed in Column (5)-(8) in Table 1, respectively.

From Table 1 and Table 2, we found that for most Seyfert 1 galaxies accretion rates are less than one sun mass per year and the accretion rates in units of the Eddington accretion rates are less than one. The higher accretion rates for Seyfert 1 galaxies showed in Bian & Zhao (2002) is due to the overestimated absolute B band magnitude, which can explain the question on super-Eddington rates found by Collin & Hure (2001). Collin & Hure (2001) also suggested that half of the objects in the sample of Kaspi et al. (2000) are accreting close to the Eddington rate or at super-Eddington rates unless BLRs is a flat thin rotating structure with the same axis as the accretion disk, close to the line of sight. Here we showed that the almost face-on BLRs, namely, small inclination, indeed lead to the sub-Eddington rates in the sub-sample of PG quasars.

In equation (2), we assumed that the gravitational instability of the accretion disk leads to BLRs, and that the BLRs size (R_{BLR}) is equal to the value of the gravitational instability radius (R_{ins}). It is possible that $R_{ins} \ll R_{BLR}$. Here we also calculated equation (1-3) assuming $R_{ins} = 0.1R_{BLR}$. Results are listed in Table 3. The inclinations are consistent with that when we assumed $R_{ins} = R_{BLR}$, while the accretion rates are larger. Equation (2) is not directly related to the inclination. The relation between R_{ins} and R_{BLR} would affect mainly the accretion rates, not the inclinations. We should notice that we used the BLRs sizes based on $H\beta$ emission line from the reverberation mapping method. Peterson & Wandel (2000) found variance emission lines spanning an order of magnitude in distance from the central source follows the expected $V \propto r^{-1/2}$ relation between the emission line size and the emission line width, and they also suggested that the gravity control broad emission line region clouds, not the radiation pressure. Based on our calculation, we found the gravitational instability would lead to the BLRs clouds and $R_{ins} \approx R_{BLR}$.

In equation (3), we omitted the random isotropic velocity and adopted the assumption of randomly-orientated BLR orbits (Bian & Zhao 2002). McLure & Dunlop (2001; 2002) modelled the $H\beta$ FWHM distribution and suggested the disk-like BLRs model is suitable for AGNs with FWHM larger than 2800 km s^{-1} . At the same time, the smaller observed $H\beta$ line width in AGNs is possibly from the isotropic velocity (Zhang & Wu 2002). The disk and isotropic figuration of the BLRs should be considered in this case. We should be cautious of our results for AGNs with small FWHM.

4 CONCLUSION

Using the nuclear absolute B band magnitude instead of the total absolute B band magnitude, we recalculated the central black hole masses, the accretion rates, and the disk inclinations to the line of sight according the method of Bian & Zhao (2002). The main conclusions can be summarized as follows:

- Smaller nuclear absolute B band luminosity in Seyfert 1 galaxies compared with that from Veron-cetty & Veron (2001) make us to obtain different results from that of Bian & Zhao (2002).
- The value of α for Seyfert 1 galaxies and quasars is different if the mean inclination of Seyfert 1 galaxies is about 30 (deg). The value of α for Seyfert 1 galaxies is about $0.1 \sim 0.01$, while the value of α for PG Quasars is about 1. The difference of α maybe lead to the different properties between Seyfert 1 galaxies and Quasars.
- Choosing smaller value of α compared with that in Bian & Zhao (2002), we found that for most Seyfert 1 galaxies are not accreting at super-Eddington rates. The higher accretion rates for Seyfert 1 galaxies showed in Bian & Zhao (2002) is due to the adopted overestimated absolute B band magnitude.

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Table 1 The properties of the 37 AGNs. Col.1: name, Col.2: absolute B band magnitude from Veron-Cetty et al. (2001), Col.3: nuclear absolute B band magnitude, Col.4:log of the reverberation mapping BH mass in M_\odot from Kaspi et al. (2000), Col.5:log of our calculated BH mass in M_\odot , Col.6: log of accretion rates in M_\odot/yr , Col.7 the accretion rate in units of Eddington accretion rate, Col.8: calculated inclinations (in deg) to our sight. The nuclear absolute B band magnitude of Seyfert 1 galaxies labelled with ^a are from Ho & Peng (2001), the rest of Seyfert 1 galaxies are from Ho (2002). The nuclear absolute B band magnitude of Quasars are from Schmidt & Green 1983.

Name	M_B	M_B^{nuc}	$\log_{10} M_{rm}$	$\log_{10} M_{cal}$	$\log_{10} \dot{M}$	\dot{m}	i
(1)	(Mag)	(Mag)	(M_\odot)	(M_\odot)	(M_\odot/yr)		(deg)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
3C120	-20.8	-20.79	7.36	9.00 ± 0.38	-1.22 ± 0.38	0.0045 ± 0.0043	5.4 ± 2.2
3C390.3	-21.6	-21.22	8.53	8.88 ± 0.35	-0.76 ± 0.40	0.017 ± 0.016	24.9 ± 10.0
Akn120	-22.2	-22.62	8.26	9.60 ± 0.38	-0.71 ± 0.38	0.0037 ± 0.0035	7.8 ± 3.2
F9	-23.0	-23.13	7.90	9.34 ± 0.38	-0.15 ± 0.38	0.025 ± 0.023	6.94 ± 2.8
IC4329A	-20.1	-19.25	6.70	6.76 ± 0.30	0.28 ± 0.43	23.63 ± 22.07	36.9 ± 14.2
Mrk79	-20.9	-19.93	7.72	8.27 ± 0.36	-0.95 ± 0.39	0.045 ± 0.043	19.6 ± 7.9
Mrk110	-20.6	-19.40	6.75	8.09 ± 0.38	-1.13 ± 0.38	0.046 ± 0.044	7.8 ± 3.2
Mrk279 ^a	-21.2	-20.55	7.62	8.18 ± 0.36	-0.50 ± 0.39	0.16 ± 0.15	19.4 ± 7.9
Mrk335 ^a	-21.7	-18.18	6.80	7.59 ± 0.37	-1.35 ± 0.39	0.09 ± 0.08	14.8 ± 6.0
Mrk509	-23.3	-22.48	7.76	9.92 ± 0.38	-1.12 ± 0.38	$6.8\text{E-}4 \pm 6.4\text{E-}4$	3.00 ± 1.2
Mrk590 ^a	-21.6	-16.46	7.25	7.20 ± 0.28	-1.78 ± 0.45	0.07 ± 0.067	41.7 ± 15.5
Mrk817 ^a	-22.3	-17.81	7.64	7.56 ± 0.27	-1.29 ± 0.45	0.1 ± 0.09	44.3 ± 16.2
NGC3227 ^a	-18.7	-16.01	7.59	7.17 ± 0.06	-1.27 ± 0.60	0.22 ± 0.20	72.4 ± 12.2
NGC3516 ^a	-20.5	-17.21	7.36	7.09 ± 0.17	-0.93 ± 0.52	0.63 ± 0.58	57.7 ± 17.2
NGC3783	-19.7	-19.01	6.97	7.24 ± 0.34	-0.43 ± 0.41	1.56 ± 1.46	27.8 ± 11.1
NGC4051 ^a	-16.8	-14.97	6.11	6.07 ± 0.28	-1.56 ± 0.44	1.67 ± 1.55	41.2 ± 15.4
NGC4151 ^a	-18.7	-19.18	7.18	7.13 ± 0.31	-0.15 ± 0.43	3.79 ± 3.54	36.4 ± 14.0
NGC4593	-19.7	-17.80	6.91	6.84 ± 0.27	-0.60 ± 0.45	2.55 ± 2.37	42.8 ± 15.8
NGC5548 ^a	-20.7	-17.29	8.09	7.77 ± 0.14	-1.45 ± 0.54	0.039 ± 0.036	61.9 ± 16.4
NGC7469 ^a	-21.6	-17.78	6.81	6.89 ± 0.31	-0.75 ± 0.42	1.669 ± 1.559	35.3 ± 13.7
PG0026	-24.0	-24.35	7.73	9.645 ± 0.74	0.277 ± 0.74	0.17027 ± 0.16991	4.24 ± 0.64
PG0052	-24.5	-23.99	8.34	9.631 ± 0.75	0.082 ± 0.76	0.11803 ± 0.11781	9.12 ± 1.40
PG0804	-23.9	-23.17	8.28	9.415 ± 0.70	-0.194 ± 0.70	0.07901 ± 0.07876	9.39 ± 1.33
PG0844	-23.1	-23.30	7.33	8.443 ± 0.86	0.857 ± 0.87	18.06383 ± 18.05147	10.09 ± 1.77
PG0953	-25.6	-25.24	8.26	10.114 ± 0.74	0.341 ± 0.74	0.06530 ± 0.06515	3.91 ± 0.59
PG1211	-24.0	-23.31	7.61	9.195 ± 0.79	0.104 ± 0.80	0.40511 ± 0.40458	5.77 ± 0.93
PG1226	-26.9	-26.47	8.74	11.066 ± 0.72	0.126 ± 0.72	0.00416 ± 0.00415	2.51 ± 0.37
PG1229	-22.4	-22.61	7.88	8.564 ± 0.91	0.338 ± 0.92	5.21516 ± 5.21290	15.66 ± 2.88
PG1307	-24.6	-24.07	8.45	9.422 ± 1.00	0.340 ± 1.01	1.09526 ± 1.09505	9.82 ± 1.99
PG1351	-24.1	-22.52	7.66	9.408 ± 0.88	-0.584 ± 0.89	0.07716 ± 0.07711	4.62 ± 0.83
PG1411	-24.7	-22.95	7.90	9.075 ± 0.85	0.013 ± 0.86	0.56902 ± 0.56858	8.97 ± 1.55
PG1426	-23.4	-22.91	8.67	9.023 ± 0.85	0.091 ± 0.87	0.80285 ± 0.80228	23.31 ± 4.00
PG1613	-23.5	-23.43	8.38	8.794 ± 0.87	0.630 ± 0.89	4.98799 ± 4.98486	22.96 ± 4.00
PG1617	-23.4	-23.06	8.44	9.030 ± 0.79	0.150 ± 0.80	0.66211 ± 0.66124	18.12 ± 2.89
PG1700	-25.8	-25.46	7.78	9.045 ± 2.14	1.542 ± 2.14	10.52923 ± 10.52919	3.67 ± 1.49
PG1704	-25.6	-25.50	7.57	10.146 ± 1.36	0.464 ± 1.36	1.41944 ± 1.41943	1.13 ± 0.32
PG2130	-22.9	-22.61	8.16	9.396 ± 0.75	-0.512 ± 0.75	0.05085 ± 0.05075	9.21 ± 1.40

Table 2 The mean and the standard deviation of inclinations in degree, log of accretion rates in M_{\odot}/yr , and the accretion rate in units of Eddington accretion rate for Seyfert 1 galaxies and for PG quasars just considering $Q = 1$ and different α .

α	1	0.1	0.05	0.01	0.001
i (Seyfert 1)	62.8 \pm 27.3	40.7 \pm 25.1	35.9 \pm 23.9	20.1 \pm 15.4	8.7 \pm 7.0
i (PG quasar)	9.3 \pm 6.7	3.9 \pm 2.8	3.2 \pm 2.3	1.6 \pm 1.2	0.7 \pm 0.5
$\log_{10}\dot{M}$ (Seyfert 1)	0.6 \pm 0.5	-0.5 \pm 0.5	-0.3 \pm 0.9	-1.3 \pm 0.5	-2.1 \pm 0.6
$\log_{10}\dot{M}$ (PG quasars)	0.1 \pm 0.4	-0.6 \pm 0.4	-0.5 \pm 0.8	-1.4 \pm 0.4	-2.1 \pm 0.4
\dot{m} (Seyfert 1)	76.7 \pm 221	3.5 \pm 10.1	3.1 \pm 5.6	0.1 \pm 0.4	0.004 \pm 0.01
\dot{m} (PG quasars)	0.06 \pm 0.1	0.002 \pm 0.004	0.5 \pm 2.0	5.6E-5 \pm 1.3E-4	1.7E-6 \pm 4.1E-6

Table 3 The same as Table 2, but for $R_{ins} = 0.1R_{BLR}$

α	1	0.1	0.05	0.01	0.001
i (Seyfert 1)	67.6 \pm 26.0	47.6 \pm 26.8	40.5 \pm 25.0	20.1 \pm 15.4	11.1 \pm 8.9
i (PG quasar)	11.9 \pm 8.5	5.0 \pm 3.6	3.9 \pm 2.8	1.6 \pm 2.1	0.9 \pm 0.6
$\log_{10}\dot{M}$ (Seyfert 1)	1.9 \pm 0.6	0.8 \pm 0.5	0.5 \pm 0.5	-0.1 \pm 0.5	-0.9 \pm 0.6
$\log_{10}\dot{M}$ (PG quasars)	1.4 \pm 0.35	0.6 \pm 0.4	0.4 \pm 0.4	-0.2 \pm 0.4	-0.9 \pm 0.4
\dot{m} (Seyfert 1)	1.7E+4 \pm 5.1E+4	876 \pm 2537	333 \pm 962	32.2 \pm 92.3	1.1 \pm 2.9
\dot{m} (PG quasars)	16.0 \pm 37.8	0.5 \pm 1.2	0.4 \pm 0.4	-0.2 \pm 0.4	4.66E-4 \pm 1.1E-3